LAB 1: Image Filtering and Hybrid Images
LSE/ESSE 4690 Advanced 3D Geospatial Techniques – Fall, 2021)

Brief:

- Assigned: September 21st, 2021
- Due: 11:59PM, September, 30th 2021
- Lab materials are available via 4690 course eClass
- Submission: through the course moodle by the due time
- Required files: report, result images and codes (with comments if necessary)

Objective:

The goal of this assignment is to write an image filtering function and use it to create hybrid images using a simplified version of the SIGGRAPH 2006 paper by Oliva, Torralba and Schyns. Hybrid images are static images that change in interpretation as a function of the viewing distance. The basic idea is that high frequency tends to dominate perception available, but, at a distance, only the low frequency (smooth) part of the signal can be seen. By blending the high frequency portion of one image with the low- frequency portion of another, you get a hybrid image that leads to different interpretations at different distances.

Details:

This project is intended to familiarize you with MATLAB and image filtering. Once you have created an image filtering function, it is relatively straightforward to construct hybrid images. If you know little about MATLAB, you will find the following tutorial on MATLAB helpful.

Image Filtering. Image filtering (or convolution) is a fundamental image processing tool. See chapter 3.2 of Szeliski and the lecture materials to learn about image filtering (specifically linear filtering). MATLAB has numerous built-in and efficient functions to perform image filtering, but you will be writing your own such function from scratch for this assignment.

More specifically, you will implement **my_imfilter()** which imitates the default behavior of the build-in imfilter() function. As specified in **my_imfilter.m**, your filtering algorithm must

1) support grayscale and color images ;
2) support arbitrary shaped filters as long as both dimensions are odd (e.g. 7x9 filters but not 4x5 filters);
3) pad the input image with zeros or reflected image content;
4) return a filtered image which is the same resolution as the input image;

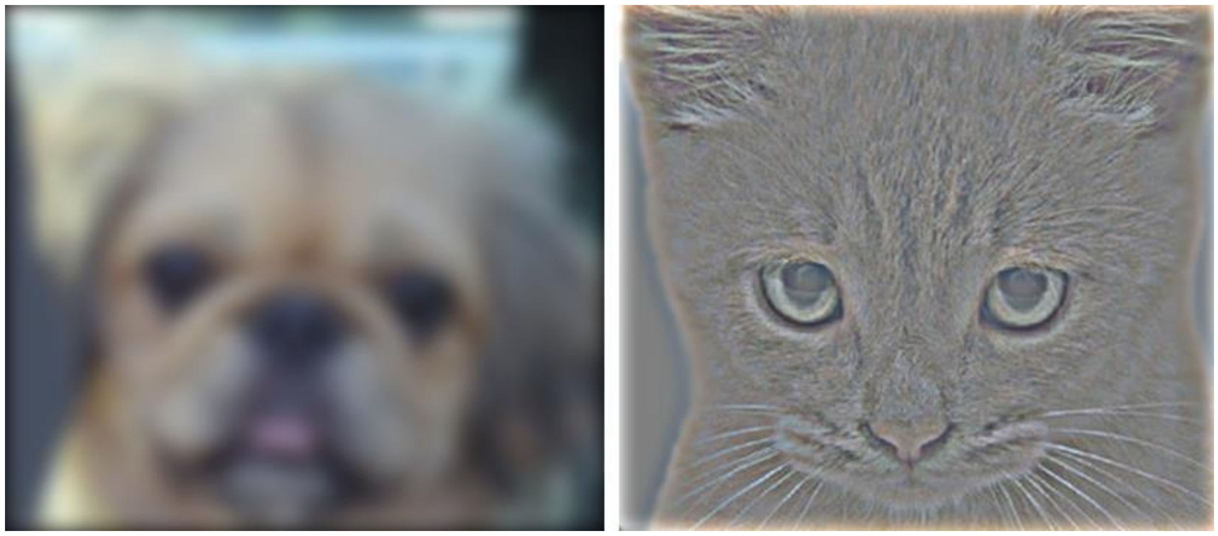
We have provided a script, proj1_test_filtering.m, to help you debug your image filtering algorithm.

Hybrid Images. A hybrid image is the sum of a low-pass filtered version of the one image and a high-pass filtered version of a second image. There is a free parameter, which can be tuned for each image pair, which controls how much high frequency to remove from the first image and how much low frequency to leave in the second image. This is called the "**cutoff-frequency**". In the original paper (Olivia et al., 2006), it is suggested to use two cutoff frequencies (one tuned for each image). Instead of producing low-frequency and high-frequency filtered images by determining the cutoff frequency in the frequency space, you are asked to generate filtered image in the image space by designing linear filters in your own ways for constructing the hybrid images.

We provide you with 5 pairs of aligned images which can be merged reasonably well into hybrid images. The alignment is important because it affects the perceptual grouping (read the paper for details). We encourage you to create additional examples (e.g. change of expression, morph between different objects, change over time, etc.). See the hybrid images project page for some inspiration.

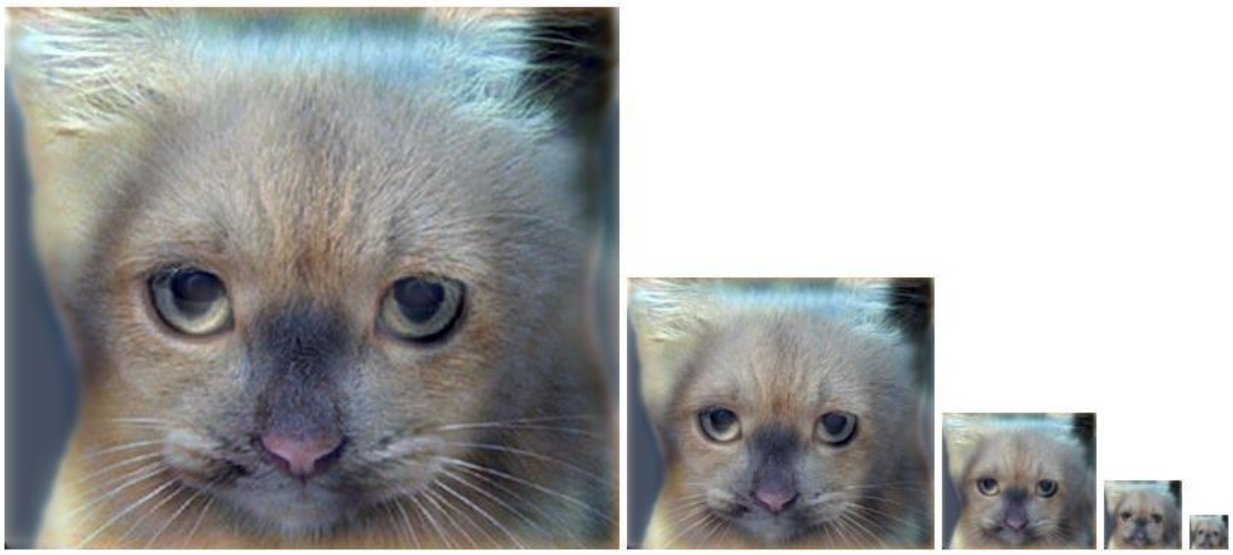
For the example shown at the top of the page, the two original images look like this:

The low-pass (blurred) and high-pass versions of these images look like this:



The high frequency image is actually zero-mean with negative values so it is visualized by adding 0.5. In the resulting visualization, bright values are positive and dark values are negative.

Adding the high and low frequencies together gives you the image at the top of this page. If you're having trouble seeing the multiple interpretations of the image, a useful way to visualize the effect is by progressively down-sampling the hybrid image as is done below:



The starter code provides a function vis_hybrid_image.m to save and display such visualizations.

Potentially useful MATLAB functions: **fspecial()** can generate the filter matrix; **padarray()** is able to pad or expand the image before running the filter over it; and other operators in the MATLAB tutorial which make it efficient to cut out image sub-windows and do the convolution (dot product) between them. **Forbidden functions** you can use for testing, but not in your final code: imfilter(), filter2(), conv2(), nlfilter(), colfilt().

Bells & Whistles (Extra Points)

For later projects, there will be more concrete extra credit suggestions. It is possible to get extra credit for this project, as well, if you come up with some clever extensions which impress the TA.

Writeup

For this project, and all other projects, you must do a project report (no min. page length; max. 12 pages with 11 fonts and single space including figures and tables). In the report, you will describe your algorithm and any decisions you made to write your algorithm in a particular way. Then you will show and discuss the results of your algorithm. In the case of this project, show the results of your filtering algorithm (the test script saves such images already) and show some of the intermediate images in the hybrid image pipeline (e.g. the low and high frequency images, which the starter code already saves for you). Also, discuss anything extra you did. Feel free to add any other information you feel is relevant.

Rubric
+50 pts: Working implementation of image filtering in my_imfilter.m
+30 pts: Working hybrid image generation
+20 pts: Writeup with several examples of hybrid images
+10 pts: Extra credit (up to ten points)
-5*n pts: Lose 5 points for every time you do not follow the instructions for the hand in format
-5*n pts: Lose 5 points for every day you delay the submission of your report and codes beyond the due date.

Credits
Assignment developed by James Hays and Derek Hoiem.